WDNR Dispersion Modeling Guidelines For Registration Permits

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Introduction

Dispersion modeling is a complex process requiring guidance in order to determine proper procedures. This document is intended to briefly explain the methodologies and guidelines concerning the atmospheric dispersion modeling performed in support of the Wisconsin Department of Natural Resources (WDNR) registration permit program. A more thorough guidance document for all dispersion modeling title, "WDNR Dispersion Modeling Guidelines" is available from the web site. All modeling completed in the State of Wisconsin should be done in accordance with these procedures as well as guidance contained in the Guideline on Air Quality Models, EPA document 40CFR51, Appendix W.

Dispersion modeling incorporates information about a facility, such as source parameters, facility layout information, and emission rates, along with meteorological data in order to predict concentrations of pollutants surrounding the facility. The point of highest impact is determined through the use of a receptor grid that is set up by the modeler. The pollutant concentration at the point of highest impact added to a pre-determined background is compared to the corresponding ambient air quality standard.

On November 9, 2005 USEPA promulgated a formal change to the Guideline on Air Quality Models, replacing ISCST3 (02035) with AERMOD (04300) as the recommended atmospheric dispersion model. The recommended use of AERMOD became effective on December 9, 2005.

How to Model Registration Permits

The first step in modeling for a source is first to determine the type of model that is needed. There are two basic categories of models, screening and refined. The classification is based on the consideration of meteorological conditions and receptor placement. Screening models search through a limited number of meteorological conditions to determine which conditions will give the highest concentration. The calculations of concentrations are only made along the plume centerline. A refined model uses historical meteorological data to give a more realistic estimate of ground level concentrations. In addition, refined models allow for calculations of concentration in two dimensions.

Screening models allow for quick analysis of impacts from a single stationary source. Since the worst case dispersion estimates are used in the concentration calculations, screening models are generally very conservative. With that in mind, if the screen model results are below regulatory standards, the need for the more time-consuming refined modeling may be eliminated. WDNR currently uses the SCREEN3 model available from USEPA.

Refined modeling uses meteorological data gathered at or near the specified location in order to calculate pollutant concentrations surrounding a source. The concentration calculations in a refined model are done on an hourly basis using a meteorological file supplied by the user.

The meteorological variables that must be defined in the refined model include wind speed and direction, atmospheric stability, and temperature. The data must meet EPA guidelines for data capture, data quality, and the inclusion of upper air data. The WDNR keeps a preprocessed set of meteorological data accessible for use with refined modeling. These data sets can be found through the Wisconsin DNR website.

On November 9, 2005 USEPA promulgated a formal change to the Guideline on Air Quality Models, replacing ISCST3 (02035) with AERMOD (04300) as the recommended atmospheric dispersion model, to become effective on December 9, 2005. On December 7, 2005, WDNR issued an implementation memo addressing the use of AERMOD for each permit type for which modeling may be conducted.

Guidance concerning the use of refined models will follow the section regarding screening models.

Screening Modeling

Restrictions and Limitations

The first step in using a screening model is to determine whether it is appropriate for the current project. If the facility is located in an area with significant topographic relief a refined dispersion model should be used to assess impact.

SCREEN Model Input Information

The following tasks should be completed before the SCREEN model can be run:

1. Compile a list of the parameters for each stack. The required parameters are:
   Stack Height (m)
   Normal Stack Gas Exit Velocity (m/s or m^3/s, or ACFM)
   Stack Inside Diameter (m)
   Normal Stack Gas Exit Temperature (K)
   Pollutants Emission Rate (g/s)

2. If the facility has more than one stack for a particular pollutant, each stack will have to be run through SCREEN and the maximum impacts added together.

3. Determine if the source is in a RURAL or URBAN area, as defined by USEPA. The only URBAN location in Wisconsin under EPA guidelines is the central city of Milwaukee.

4. Building heights in the vicinity of the facility need to be examined to determine if the plume is affected by downwash. Building heights must be considered in relation to the building's width to determine the most significant building. To determine the controlling building, compute the effective building index (H_e) for each structure within a horizontal distance equivalent to five times the height of the stack.

   $$H_e = H_b + 1.5(L_b)$$

   Where: H_e is the effective building index
   H_b is the actual building height
   L_b is the lesser of the building height or maximum width (usually the diagonal)

   The structure with the largest H_e is considered the controlling building. Determine the building height, the minimum building width, and the maximum building width for the controlling building. Enter the controlling building height and lateral dimensions into SCREEN3.

5. The receptors should extend beyond the point of maximum impact, so when using the automated distance array, the minimum distance should be 50 meters and the maximum distance 5000 meters.

Output Analysis

The maximum concentration is found in the output file created by the SCREEN model. This concentration is the maximum in a one-hour period, so it must be converted to the proper averaging period. Use the conversion factors in the following chart (as determined by USEPA) to convert to the time period of interest:

Table 4.3
SCREEN Output Conversion Factors

To Convert to	Multiply Concentration by
3 hour	0.9
8 hour	0.7
24 hour	0.4
Annual	0.08

The total concentration is determined by adding the model output to the appropriate background concentrations. This calculation is not performed for HAPs, as currently there are no regional background values for HAPs.

Refined Modeling

Required Information

A variety of information is needed in order to perform air quality dispersion modeling with AERMOD, including stack height, stack inside diameter, exit gas velocity and exit gas temperature. The data should be for each exhaust to the atmosphere, not combinations of stacks.

The following sections identify information that is necessary for setting up and running a refined modeling analysis using AERMOD. The information is mostly applicable to permit writers at WDNR, but is presented here so that external customers understand all the information necessary for a modeling analysis.

Model Input Information

General Company Information

Name, FID Number, Permit Number, Facility Address, City, County, Permit Contact (Name and Phone Number)

Dispersion Model and Options

Most dispersion modeling projects in the State of Wisconsin should be completed using AERMOD, according to WDNR guidance. The most recent version of AERMOD should be used at all times.

Dispersion Coefficients

Most locations in Wisconsin are defined as "Rural" using the Auer Land Use Method. In 2004, the modeling team conducted a land use analysis in order to identify urban locations within the state. The only "Urban" location found in Wisconsin is found in the Milwaukee area. A memo was written detailing the area and a map was made. For urban locations, please use a population of 600,000 and a roughness length of 0.6 meters.

Source Information

The following information should be provided within the modeling request:

Stack Parameters (for all stacks; combined parameters should not be used in the refined analysis)

- Stack height (feet or meters) as measured from ground
- Stack inside diameter (feet or meters) with an indication of whether the stack exit opening is circular or rectangular
- Normal or average stack exit flow rate (used to calculate exit velocity) with an indication of the stack orientation and obstruction status. Any stack that has a vertical orientation and has unobstructed flow (or has a rain hat that opens when there is pollutant discharge) may have exit velocity calculated and included in the modeling input files. A stack that either deviates from the vertical by more than 10 degrees and/or is obstructed will be assigned a default exit velocity of 0.10 meters per second.

- Normal or average stack gas exit temperature

- Maximum hourly emission rate in pounds per hour for all pollutants requiring modeling

Plot plan identifying all locations of all stacks, all buildings (with heights clearly identified), true north, location of facility with respect to nearby roads or other identifying landmarks, fence lines (if applicable), and property line. Stack and building locations will be measured in Universal Transverse Mercator (UTM) North American Datum 1983 (NAD83) with true north along the y-axis. Buildings at the facility, as well as neighboring buildings that are not part of the facility should be examined to determine if they affect the source. A building influences a stack if the distance from the nearest building edge to the stack is less than five times the building height. Or, all buildings at the facility and any neighboring building that may be thought to have an impact can be measured and input to the BPIPPRM (Building Profile Input Program for PRiMe). The output of BPIPPRM will include all buildings that cause downwash.

Receptor Information
Receptors should be placed where impact will be the greatest. The selection of receptor sites should be done on a case-by-case basis, taking into account the topography, climatology, proximity of neighborhoods, etc., but the resolution of the receptor grid in the area of maximum impact should be 25 meters.

Ambient Air
Receptors should be placed in locations such that they are measuring "ambient air" as defined by USEPA. The definition states that "the air everywhere outside of contiguous plant property to which public access is precluded by a fence or other effective physical barrier should be considered in locating receptors. Specifically, for stationary source modeling, receptors should be placed anywhere outside inaccessible plant property." Wisconsin uses the following in defining a fence:

> *A fence shall be defined as any permanent, effective, physical barrier that impedes public access to a facility at all times. For refined modeling purposes, the air everywhere outside this barrier should be considered when locating receptors. For example, receptors should be included over unfenced plant property, over bodies of water, over roadways, and over property owned by other sources. Property that is not completely enclosed by a fence is considered ambient air.*

It should be noted that receptor placement in the case of HAP modeling does not need to follow the fence line guidelines, as NR445 mandates that all modeling of regulated toxics begin at the property line.

Terrain

AERMOD is specifically designed to handle the inclusion of terrain in modeling. Therefore, terrain should be used in analyses done for facilities in Wisconsin. If there are specific cases where the use of terrain is suspect, the cases should be brought to the attention of SSMT and a decision will be made regarding its use on a case-by-case basis.

Terrain data should be processed using AERMAP according to the procedures described in the AERMAP user's guide.

Meteorological Data

In the AERMOD Implementation Guide, USEPA addresses the selection of surface characteristics for facilities. The guide stresses the importance of using surface characteristics specific to the instrumentation location, not the source(s) site. WDNR has processed several sets of NWS meteorological data for use in AERMOD. The AERMOD implementation guide suggests that if the "nearest NWS meteorological site's surface characteristics are determined to NOT be representative of the application site, it may be possible that another nearby NWS site may be representative of both weather parameters and surface characteristics." WDNR supports this position and suggests the use of the preprocessed meteorological data provided here. If a situation arises where site-specific meteorological data may be warranted, the applicant should contact WDNR before proceeding in order to settle on a protocol for assembling the meteorological data prior to any modeling. When using the preprocessed NWS meteorological data, WDNR requires running five consecutive meteorological data years for each pollutant applicable. The WDNR preprocessed meteorological data is available from the Stationary Source Modeling website. If an applicant is performing modeling and is unsure which meteorological data set to use, the applicant should contact the appropriate WDNR regional contact.

For an in-depth guide to the use of AERMOD (04300), please see the *User's Guide for the AMS/EPA Regulatory Model AERMOD*.

Model Output Analysis

When using NWS preprocessed meteorological data, refined modeling analyses should be completed using all five years of sequential meteorological data. All concentrations calculated by the model are based on a one-hour value averaged over the requisite time period. The modeled concentrations are compared to the appropriate standard. The monthly, quarterly, and annual standards, PSD increments, and all AAS may never be exceeded, so the first highest value is examined for making the comparison. The short-term NAAQS standards (1 hour, 3 hour, 8 hour, and 24 hour) may be exceeded once per calendar year, so modeled results are given as the highest of the five second-highest value from the five years of meteorological data (i.e. one value per year).

Background Concentrations

Before the model output can be compared to the ambient standard, a regional background concentration must be added in. The intent of the background value is to assess the total impact on human health by examining all sources of air contaminants, including those sources that are not modeled, but exist within the region. Examples of sources included in the background concentration are other point sources, mobile sources, other fugitive sources, and fugitive dust from a number of sources including but not limited to coal piles and roadways. Background concentrations are derived from several years of actual monitoring data collected at sites around the state. In order to ensure that the numbers are as accurate as possible, the monitors are situated such that they are not directly affected by a particular source. The background values are added to the modeled concentration in order to determine the maximum impact. The background values are updated on a periodic basis and are available on the WDNR website, or from any SSMT member. Background concentrations are not used in an increment analysis.

Future Modeling Threshold

As part of the registration permit program, if the modeled PM impacts from the facility are below a set threshold, then future changes at the facility do not need to be modeled. For the counties in Wisconsin that have higher background concentrations, or are in more developed areas, this threshold is 30.0 $\mu g/m^3$. In the remainder of the state, the threshold is 60.0 $\mu g/m^3$. The map on the final page of this document illustrates the current status of all counties. It will be updated as necessary to reflect changing conditions.

Reducing Impact

Once the appropriate background value has been added to the modeled concentration, the total is compared to the NAAQS standards. If the maximum impact is greater than the applicable NAAQS, then the facility does not qualify for a registration permit. Upon re-submittal, the permit applicant may want to explore opportunities to reduce the impact. A list of some solutions is included here:

1. The most logical place (from a modeling standpoint) to begin is with a reduction in the emission rate. The gaussian dispersion equation upon which dispersion models are based assumes concentration is directly proportional to the emission rate. This relationship guarantees that the most direct way to reduce the impact of a source is to reduce emissions. is:

2. The second recommendation is to double check stack parameters. Also double check for a fence. In many cases, the fenceline has not been noted on the plot plan and so is not taken into account in the modeling. If a plot showing the position of the fence can be provided, this information can be included in the modeling.

3. The next recommendation is to thoroughly review the plot plan and accurately label all building tier heights, both at the eave and the peak. AERMOD is sensitive to building effects, so providing building heights as the structure was actually built helps insure the accuracy of the analysis.

4. Another way to reduce concentration is to alter the characteristics of the exit gas itself. A way to go about this is to remove rain-hats and/or turn horizontal discharges upward. This is because vertical, unobstructed stacks will give the best dispersion.

5. If these simple recommendations do not work, another way to mitigate an exceedance is by raising the stack. Increasing the stack height physically moves the effluent further from the ground. It also reduces the downwash effects of nearby buildings. The amount of height increase required to reduce concentration depends on a number of factors including stacks gas exit velocity and temperature, nearby building heights, and the physical layout of the facility. No standard ratio can be used, which means that each new scenario must be remodeled.

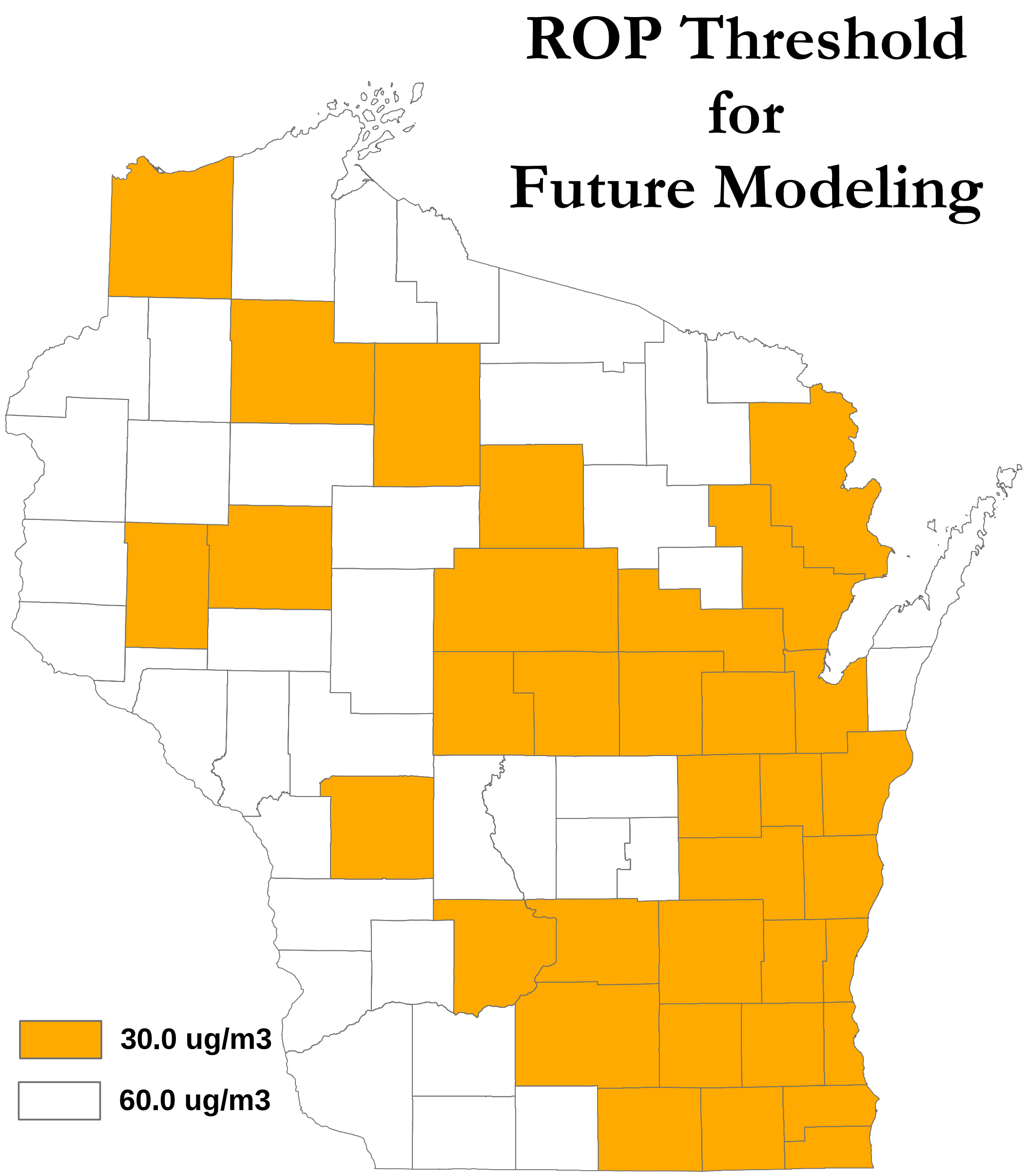
5. Occasionally, facilities disagree with the use of maximum emissions and normal flow in modeling. If a facility would like a modeler to consider the maximum flow and temperature along with the maximum emissions, it will be necessary for the facility and the permit engineer to provide the corresponding information for varying loads, so that a load analysis can be performed. Standard modeling practices avoid this by using the normal flow and temperature along with the maximum emissions, thus encompassing all possible operating scenarios. Consult a modeling team member for more information on the requirements, as they can vary slightly based on the process in question.

Staff Contacts

For any questions related to modeling, please contact one of the WDNR modelers listed below. The contacts are assigned to regions, so for questions specific to a particular region, please contact the appropriate person.

John Roth - 608 267-0805 – Team Leader, Northeast Region
Gail Good - 608 267-0803 – Southeast, South Central Regions
Jeff Sims - 608 266-0151 – Northern, West Central Regions
Dan Meinen - 608 266-6910 – Modeling LTE

Future Modeling Threshold Map



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